Universidad Popular del Cesar

Reconocimiento de Patrones

Version 2024-I

Local Binary Patterns

[Capítulo 2]

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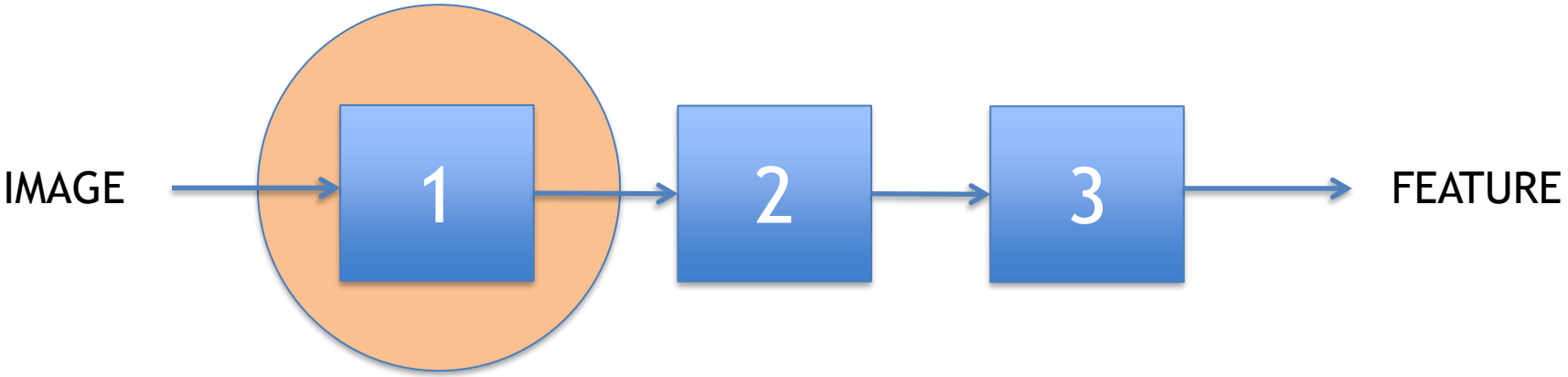
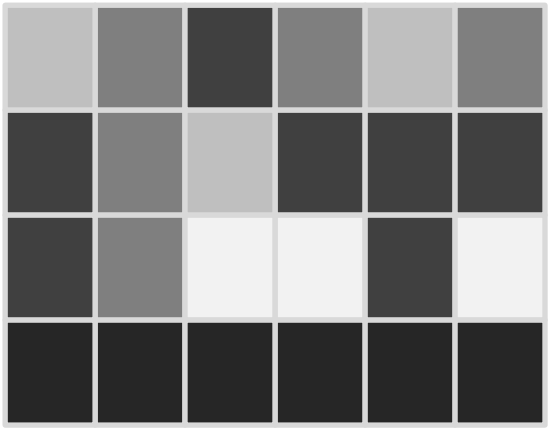
Local Binary Patterns

1. Coding
2. Mapping
3. Histogram

Local Binary Patterns

1. Coding
2. Mapping
3. Histogram



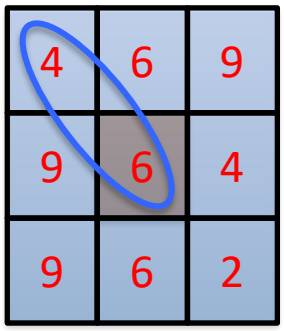


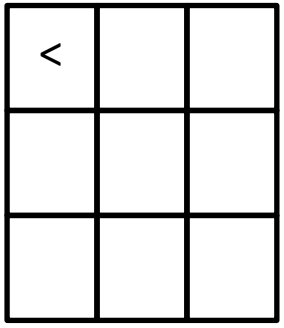

4 6 9 6 4 6
9 6 4 9 9 9
9 6 2 2 9 2
10 10 10 10 10 10

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

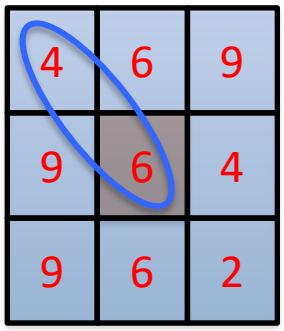
4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

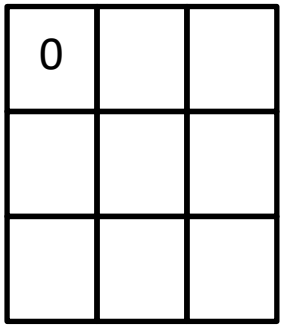
4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10





4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10





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1: ≥

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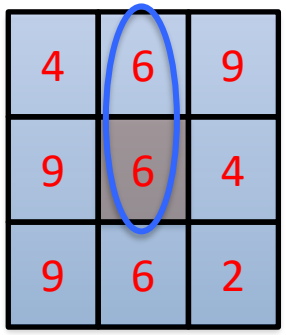
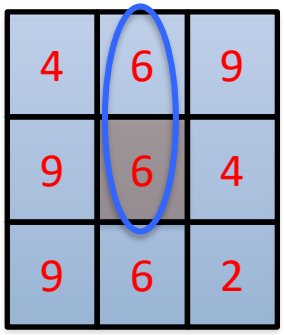
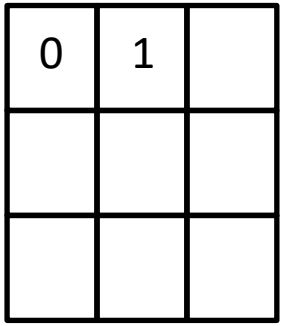
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



0	≥	

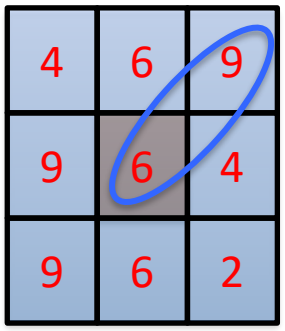
0: <
1: ≥





0: <
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



0	1	1

0: <
1: ≥

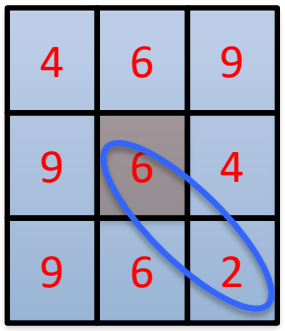
4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
		0

0: <
1: ≥

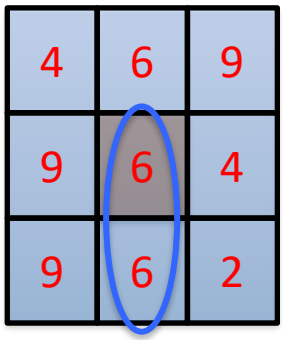
4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



0	1	1
		0
		0

0: <
1: ≥

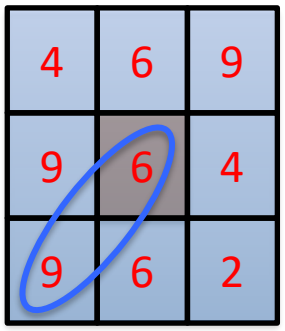
4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



0	1	1
		0
	1	0

0: <
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



0	1	1
		0
1	1	0

0: <
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
1		0
1	1	0

0: <
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
1		0
1	1	0

x

1	2	4
128	+	8
64	32	16

= 2+4+32+64+128 = 230

0: <
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
1		0
1	1	0

x

1	2	4
128	+	8
64	32	16

= 2+4+32+64+128 = 230

0: <
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

	230				

4	6	9
9	6	4
9	6	2

0: <
1: ≥

0	1	1
1		0
1	1	0

x

1	2	4
128	+	8
64	32	16

= 2+4+32+64+128 = 230

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

	230	?			

6	9	6
6	4	9
6	2	2

0: <
1: ≥

x

1	2	4
128	+	8
64	32	16

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

	230	207			

6	9	6
6	4	9
6	2	2

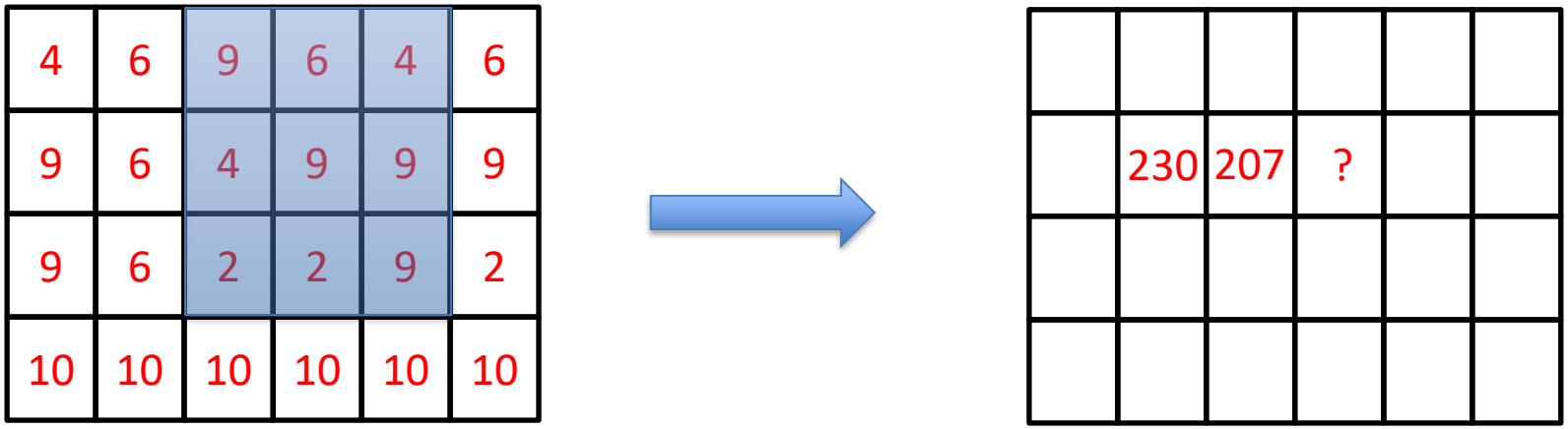
0: <
1: ≥

1	1	1
1		1
1	0	0

x

1	2	4
128	+	8
64	32	16

= 1+2+4+8+64+128 = 207


4 6 9 6 4 6
9 6 4 9 9 9
9 6 2 2 9 2
10 10 10 10 10 10
230 207 ?

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

	230	207	25		

9	6	4
4	9	9
2	2	9

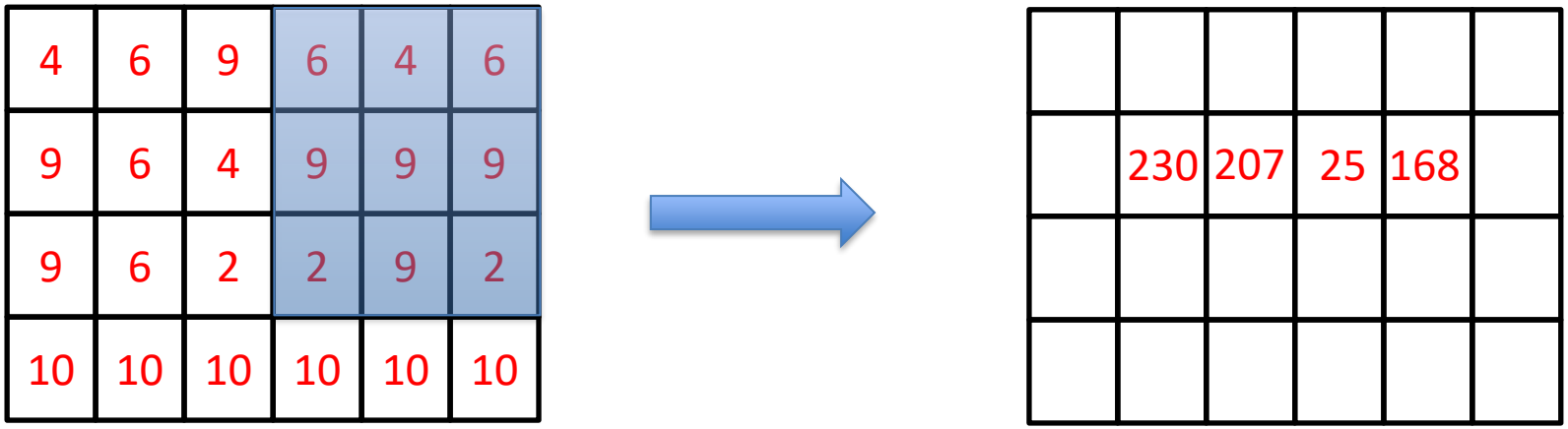
0: <
1: ≥

1	0	0
0		1
0	0	1

x

1	2	4
128	+	8
64	32	16

= 1+8+16 = 25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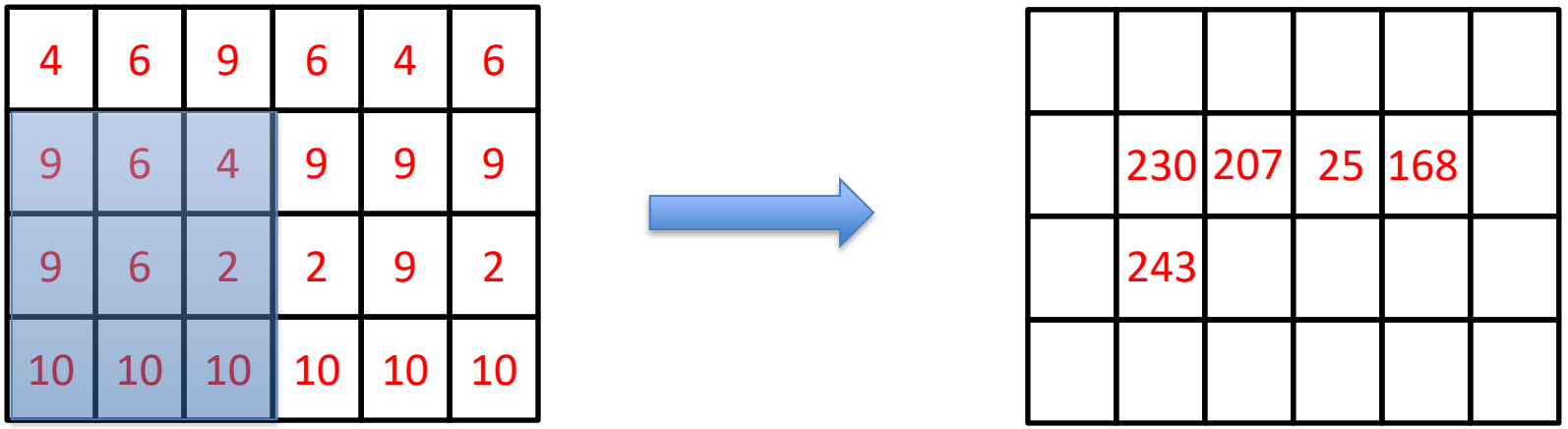
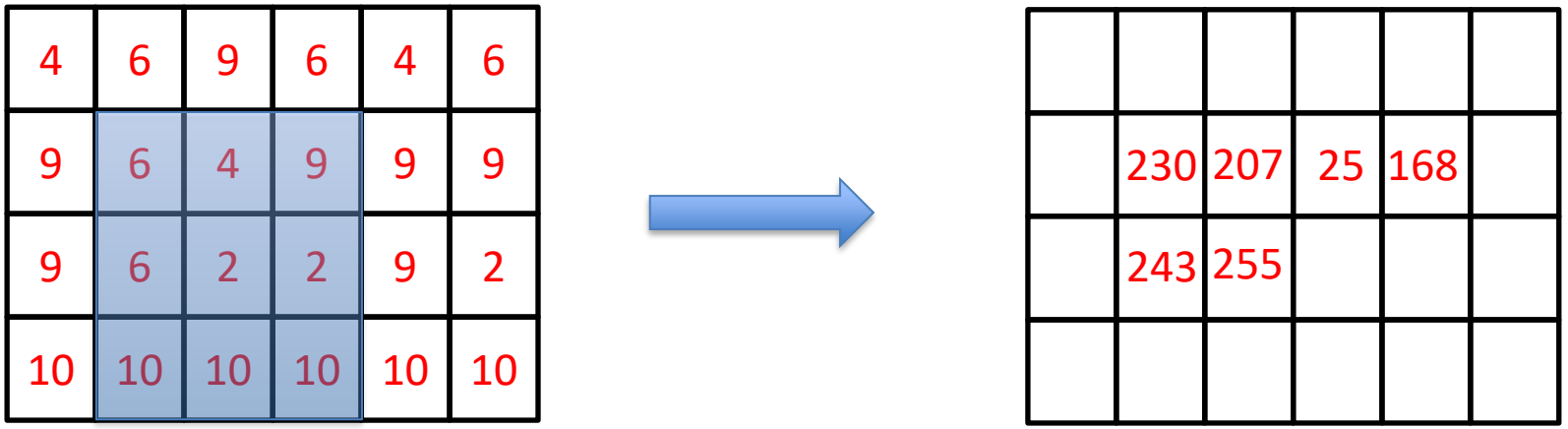
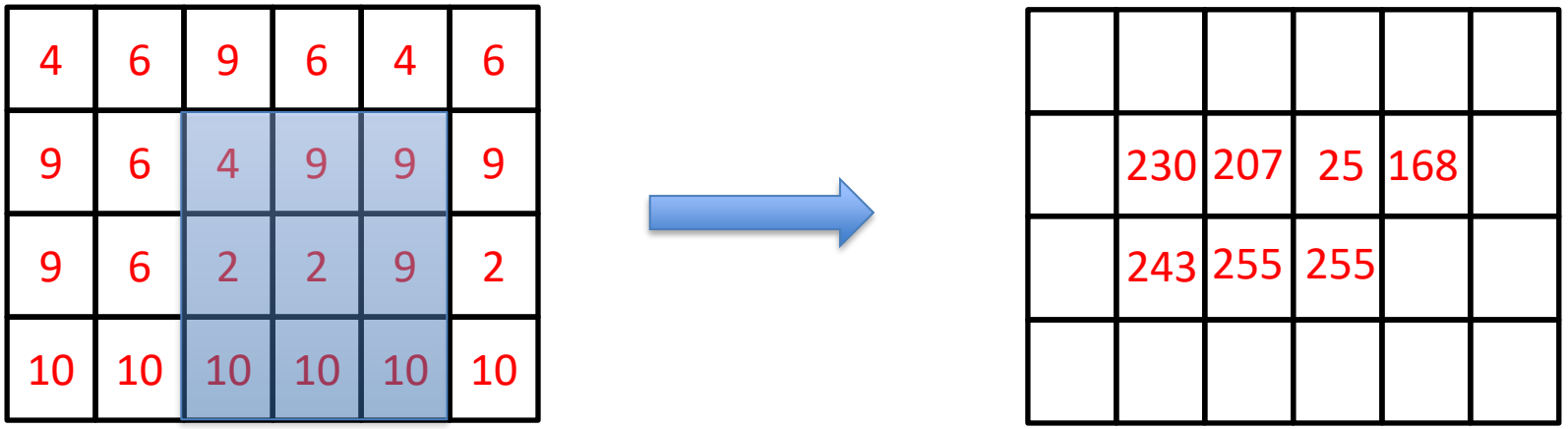
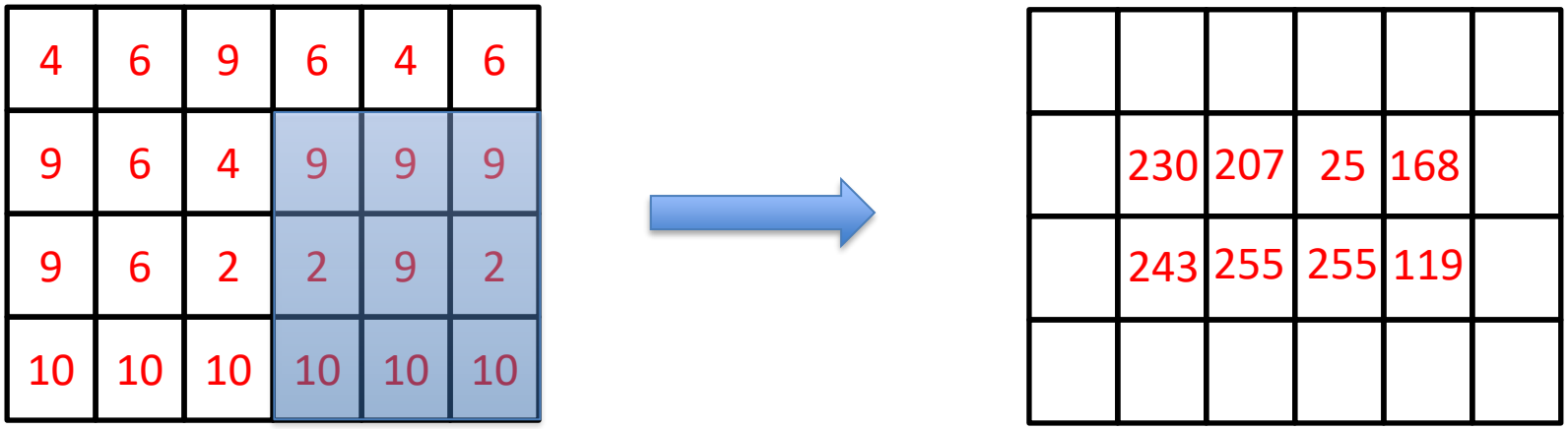
9 6 4 9 9 9
9 6 2 2 9 2
10 10 10 10 10 10
230 207 25 168


4 6 9 6 4 6
9 6 4 9 9 9
9 6 2 2 9 2
10 10 10 10 10 10
230 207 25 168
243

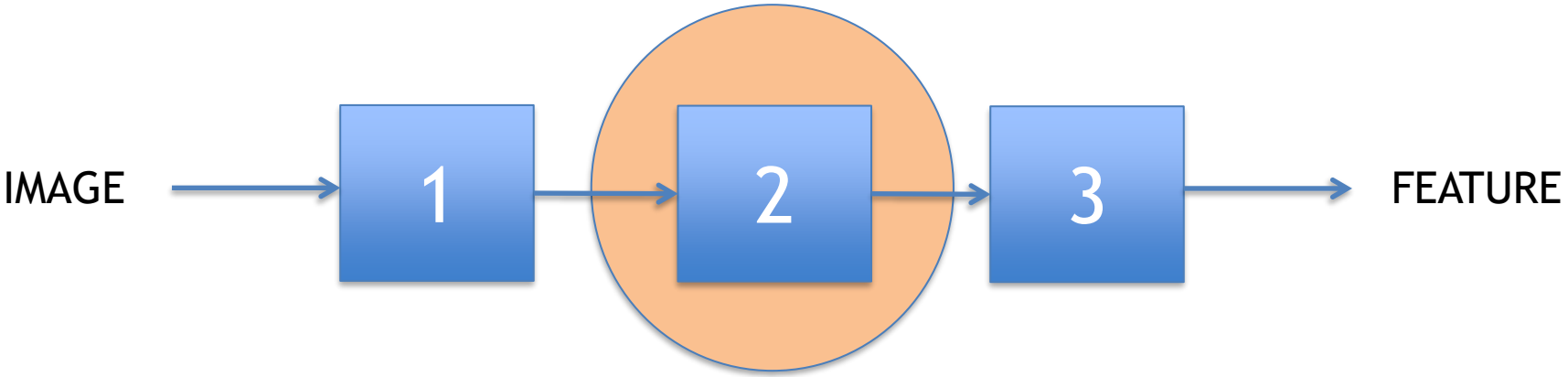

4 6 9 6 4 6
9 6 4 9 9 9
9 6 2 2 9 2
10 10 10 10 10 10
230 207 25 168
243 255

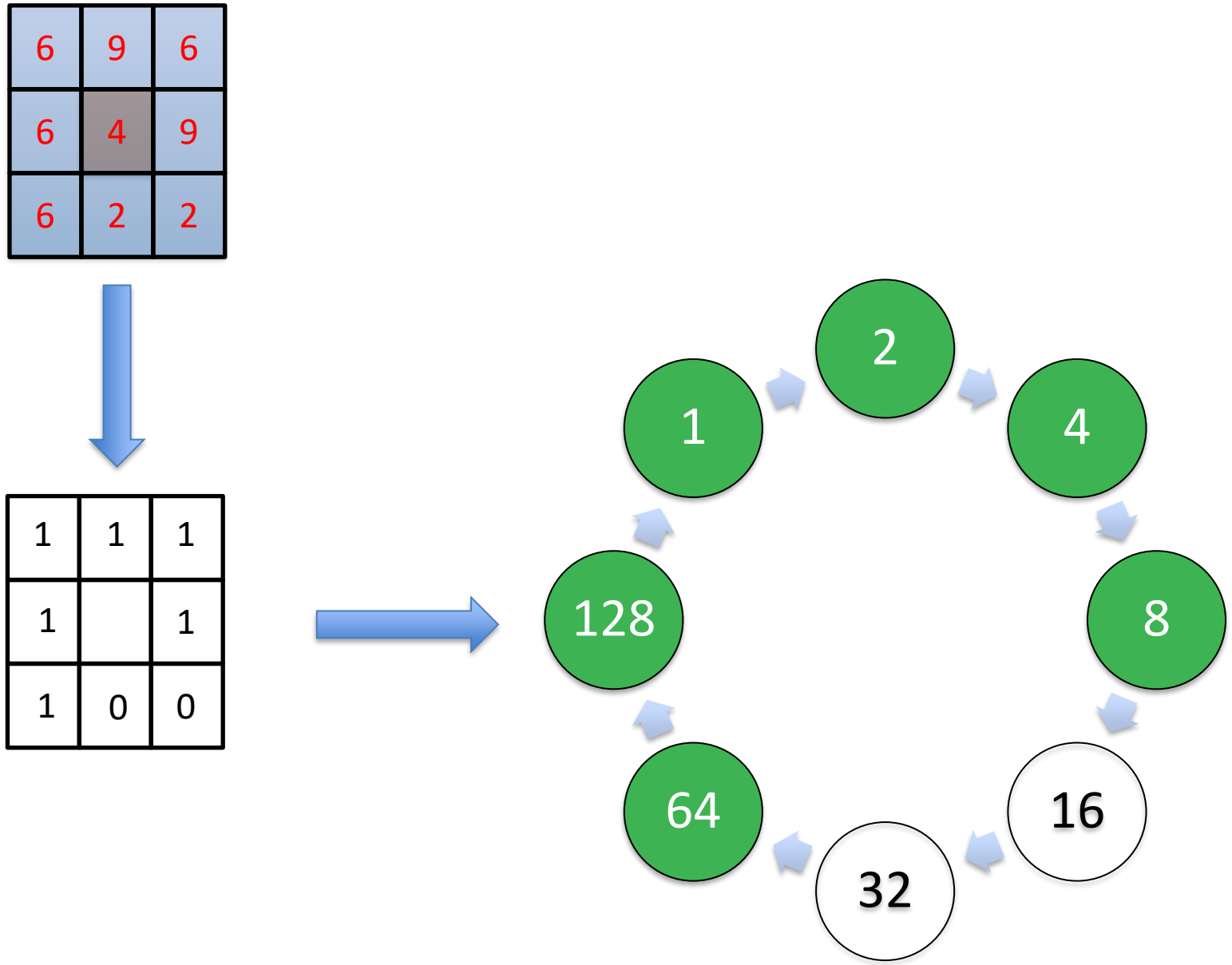

4 6 9 6 4 6
9 6 4 9 9 9
9 6 2 2 9 2
10 10 10 10 10 10
230 207 25 168
243 255 255

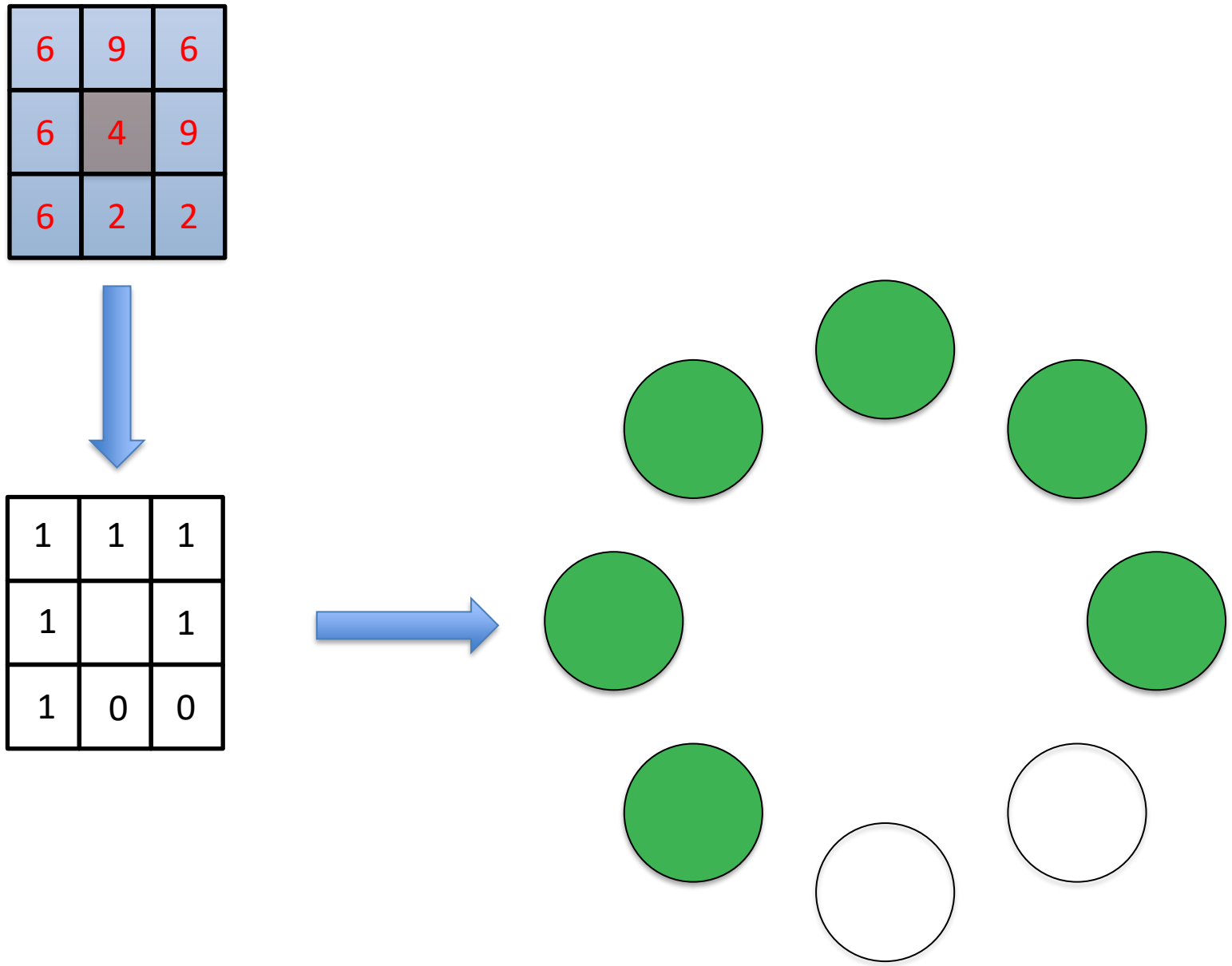

4 6 9 6 4 6
9 6 4 9 9 9
9 6 2 2 9 2
10 10 10 10 10 10
230 207 25 168
243 255 255 119

Local Binary Patterns

1. Coding
2. Mapping
3. Histogram

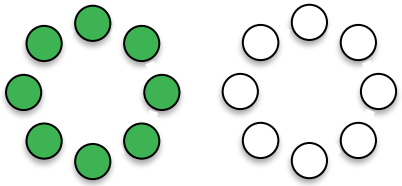



6 9 6
6 4 9
6 2 2
1 1 1
1 1
1 0 0
2
1
4
128
8
64
16
32

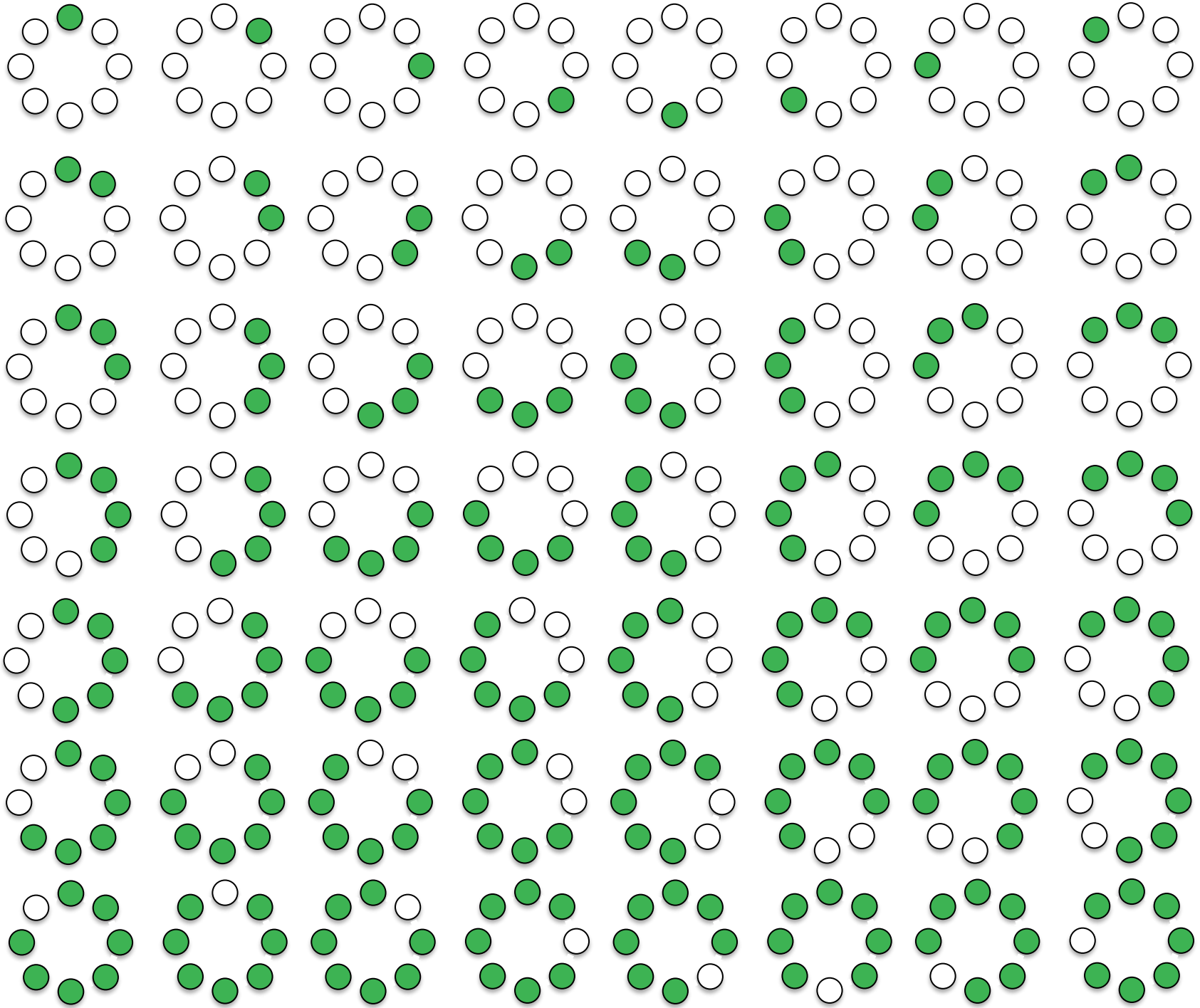

6 9 6
6 4 9
6 2 2
1 1 1
1 1
1 0 0

Uniform patterns

U = 0



U = 2



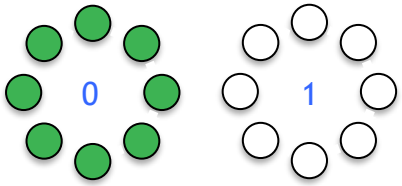
Uniform patterns

2 + 56 = 58 patterns

U = 0

2 patterns

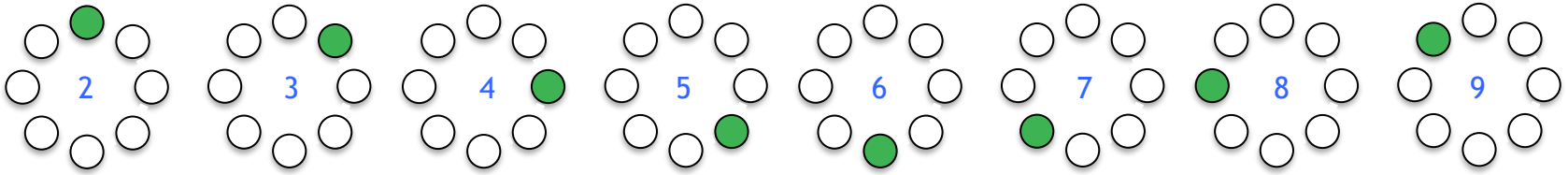
{0,1}



U = 2

8x7 = 56 patterns

{2, 3, … 57}

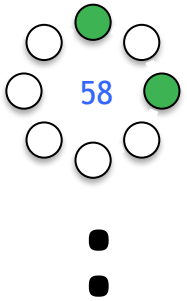


Non-uniform patterns

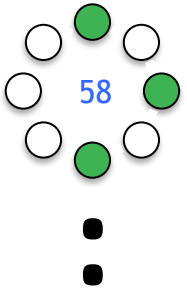
256 -58 = 198 patterns

{58}

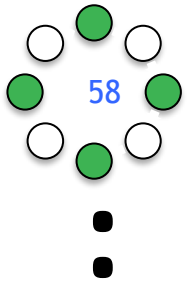
U = 4

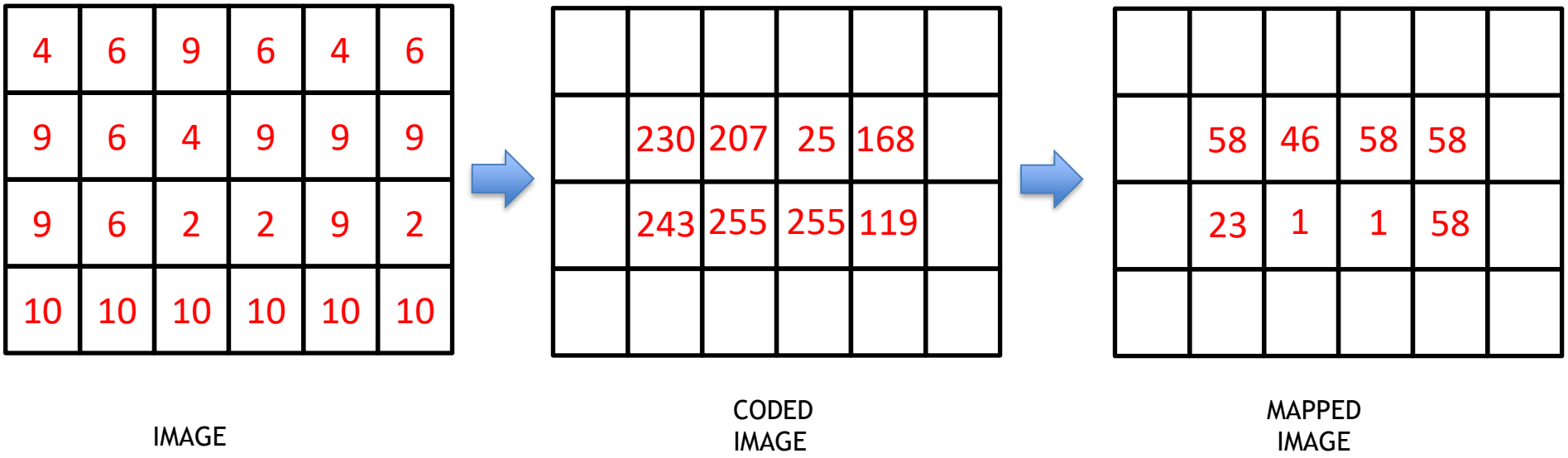


U = 6



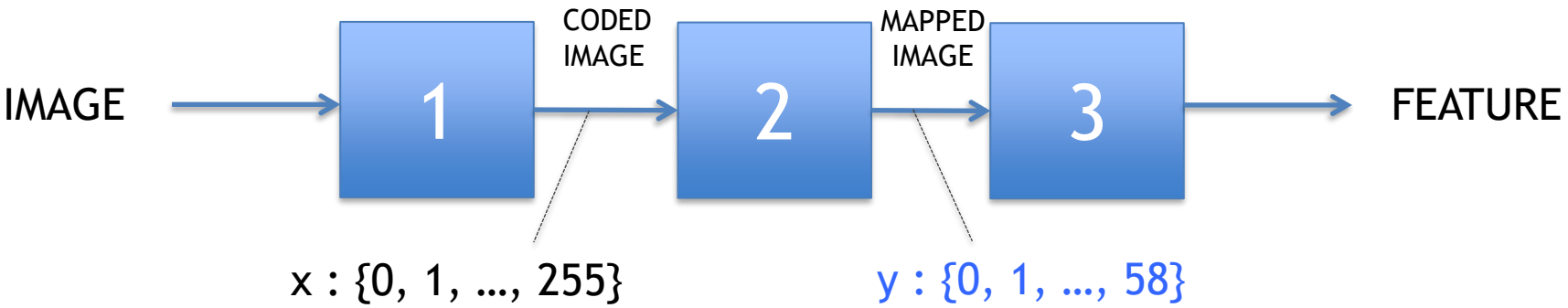
U = 8




4 6 9 6 4 6
9 6 4 9 9 9
9 6 2 2 9 2
10 10 10 10 10 10
230 207 25 168
243 255 255 119
58 46 58 58
23 1 1 58
IMAGE
CODED IMAGE
MAPPED IMAGE

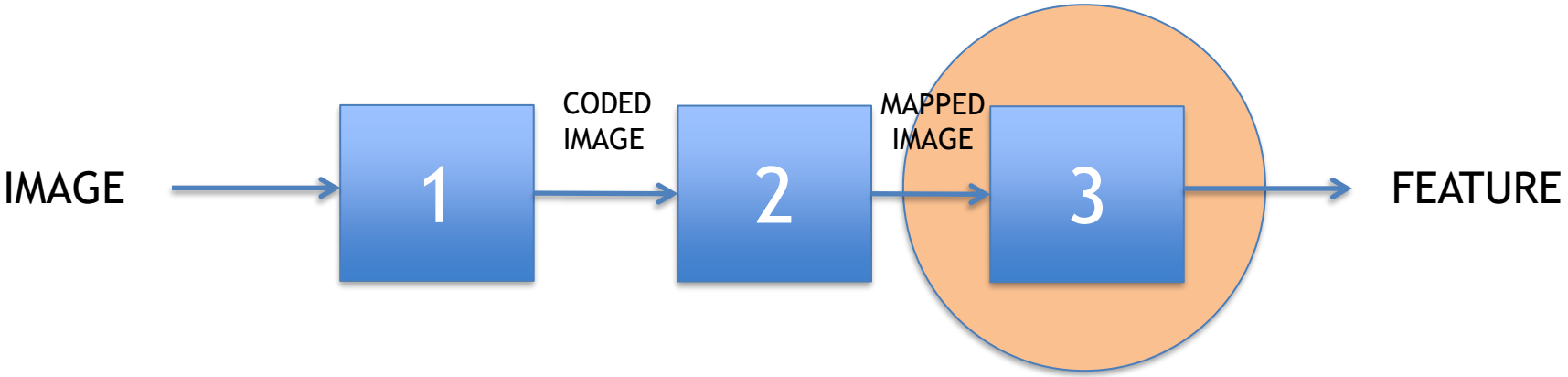
Local Binary Patterns

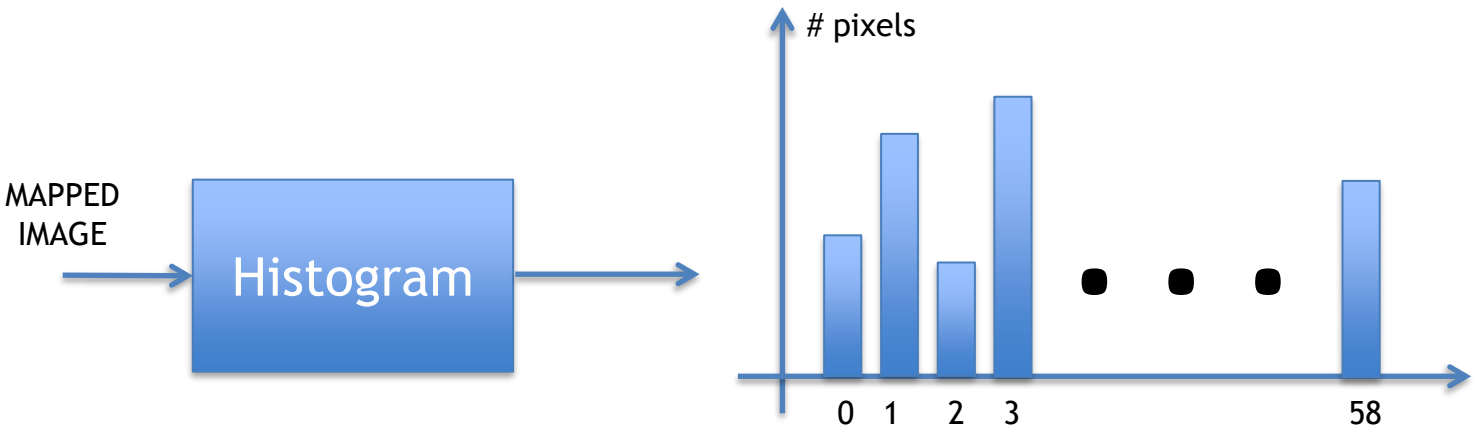
1. Coding
2. Mapping
3. Histogram



Local Binary Patterns

1. Coding
2. Mapping
3. Histogram

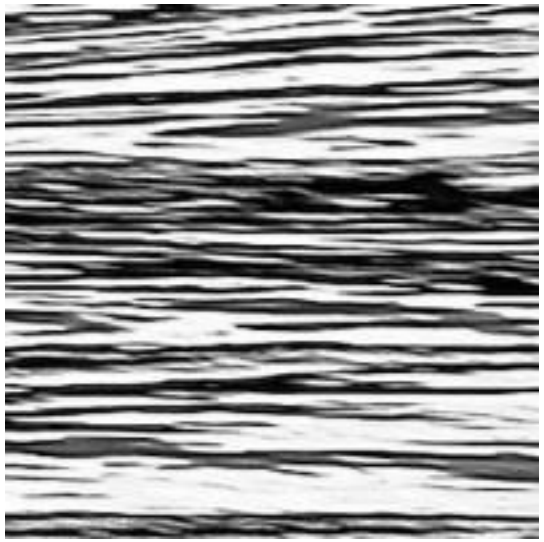


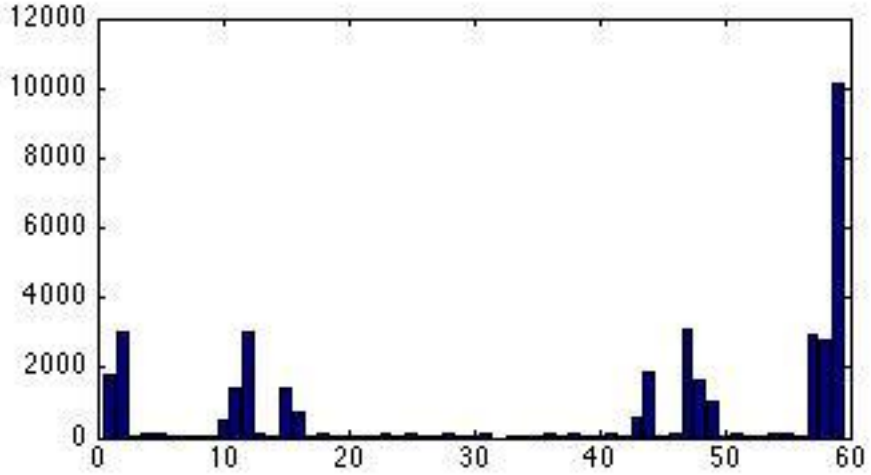


The image is described as a vector of 59 elements. Similar images have similar LBP features!!!

Local Binary Patterns

Examples
Texture Images

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6000
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2000
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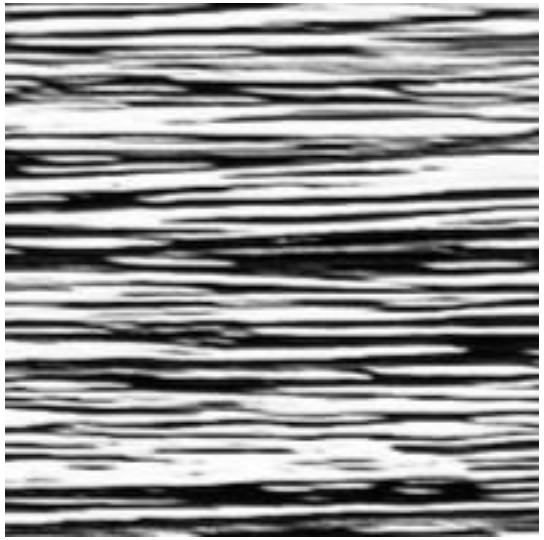
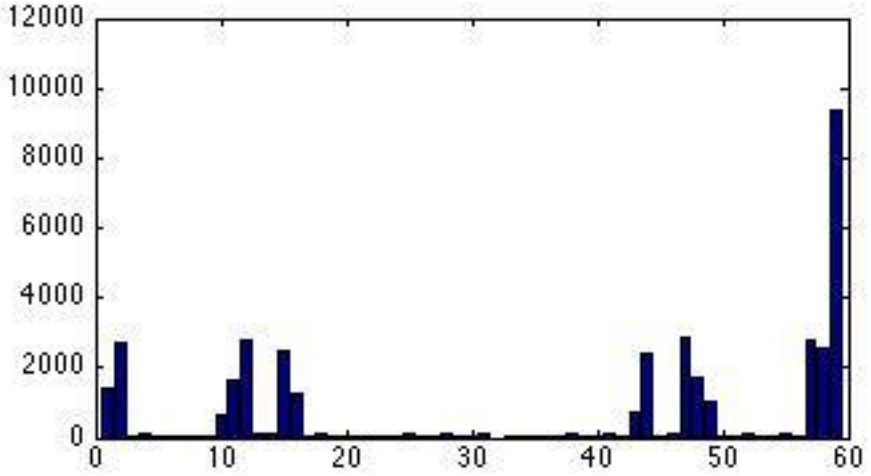
0
10
20
30
40
50
60

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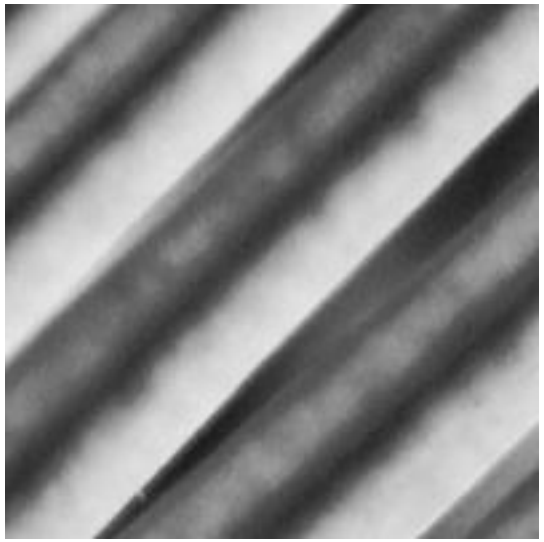
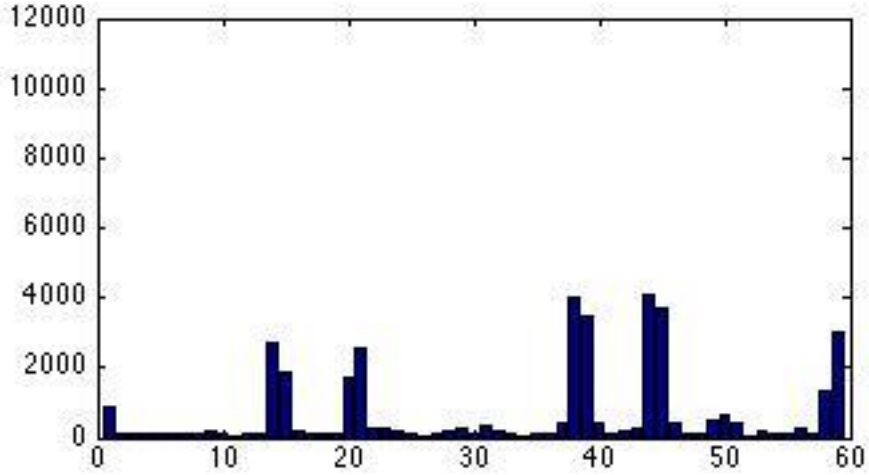
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60

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8000
6000
4000
2000
0
0
10
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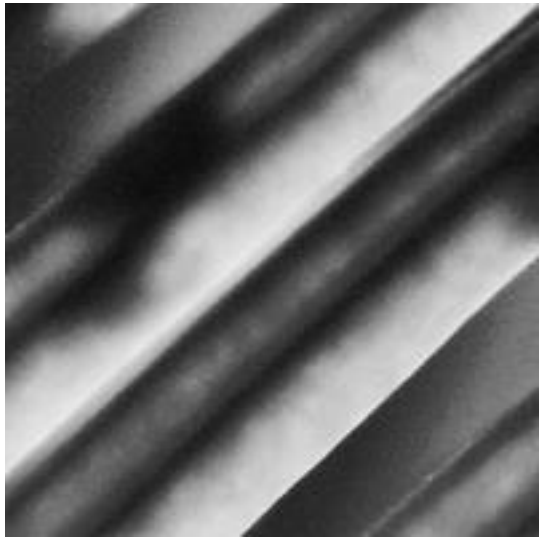
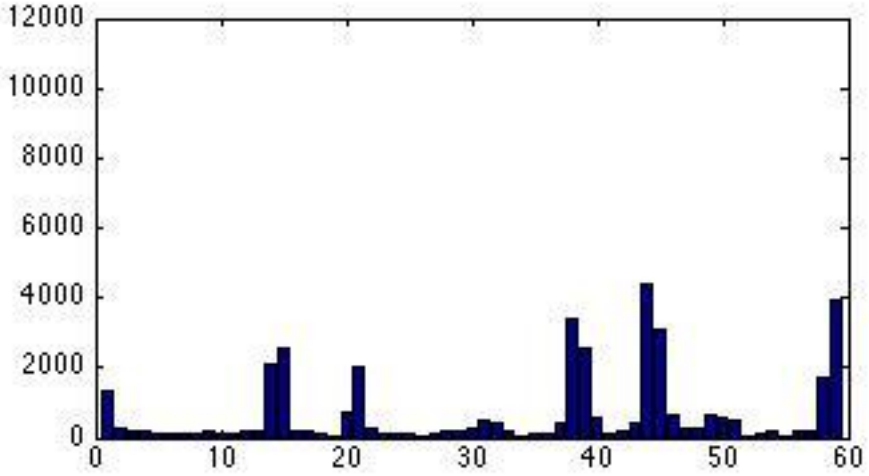
30
40
50
60




12000
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8000
6000
4000
2000
0
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30
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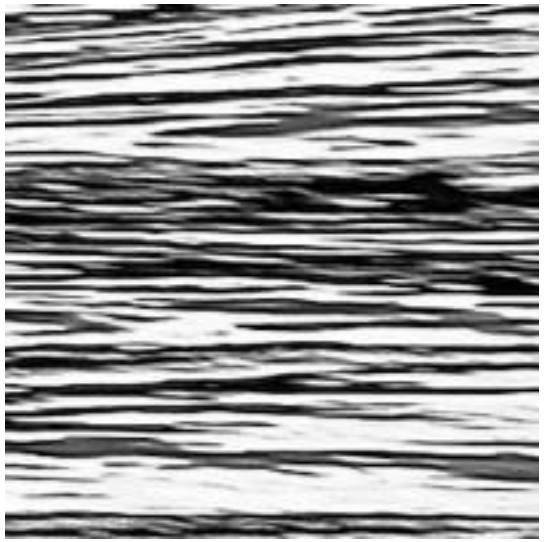
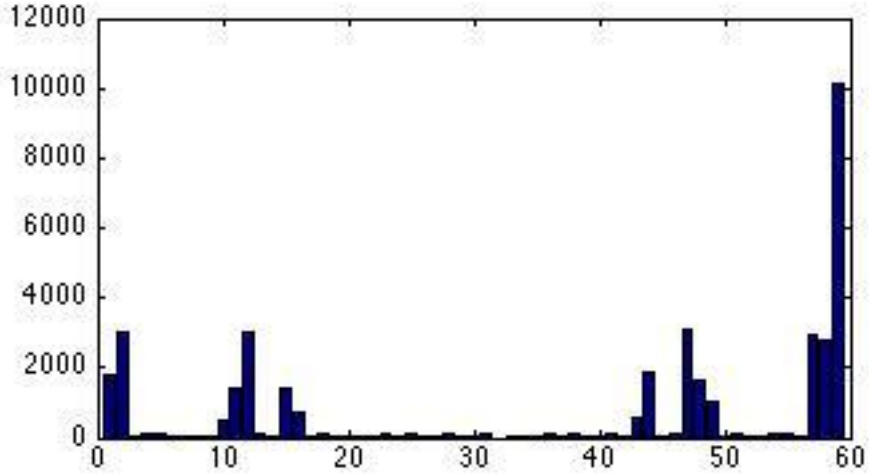
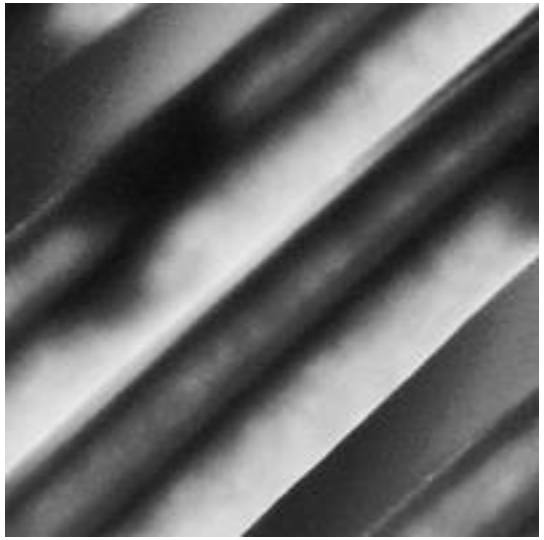
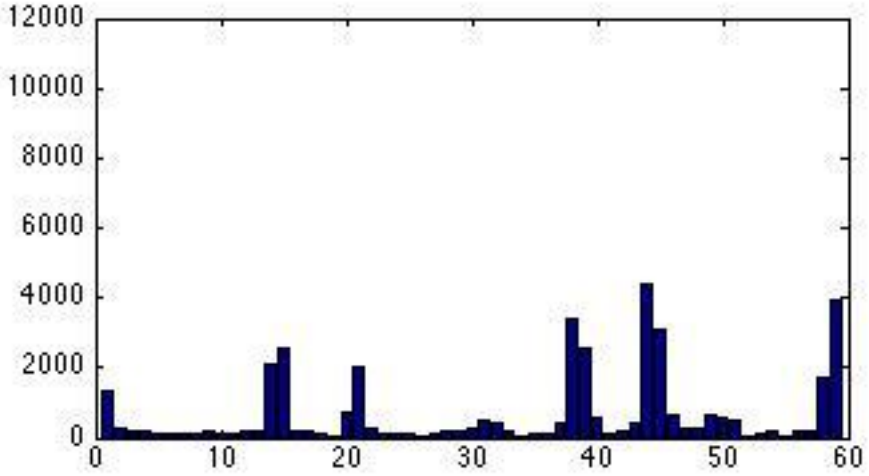
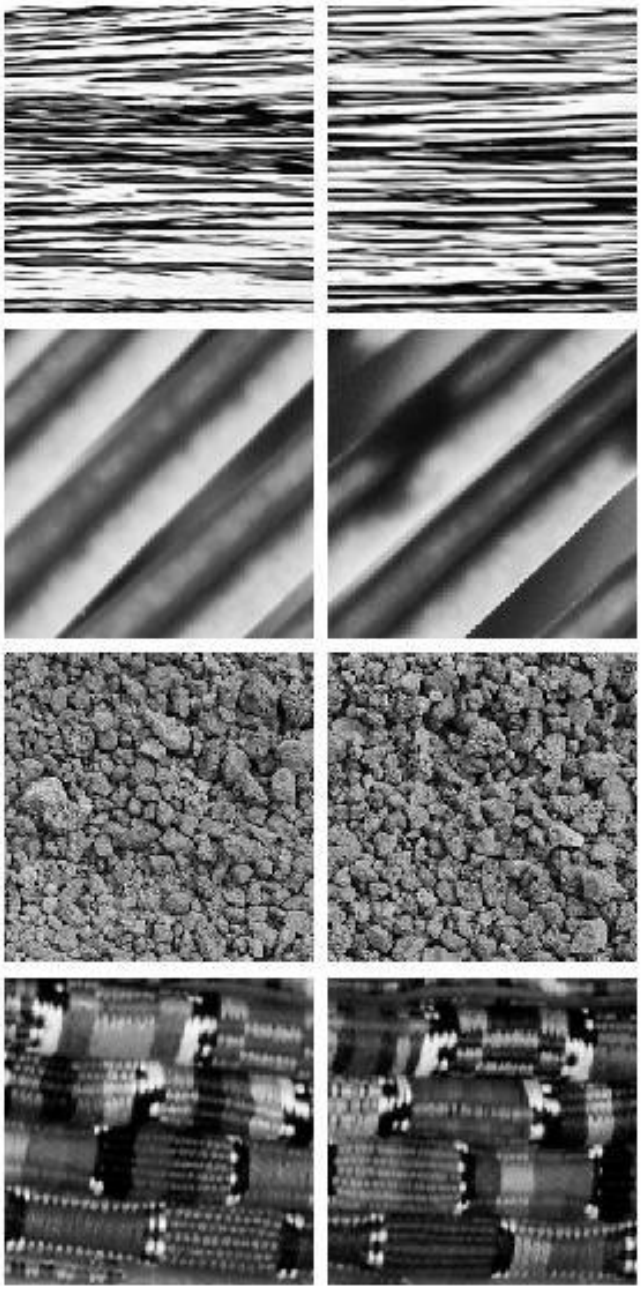
50
60

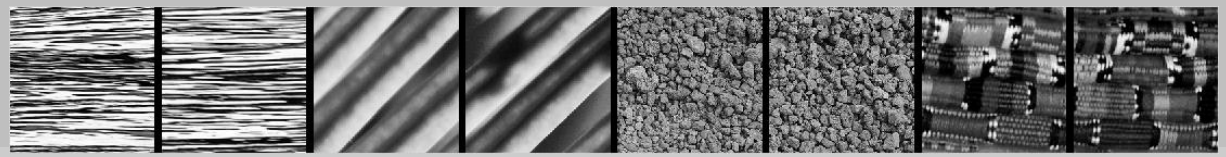


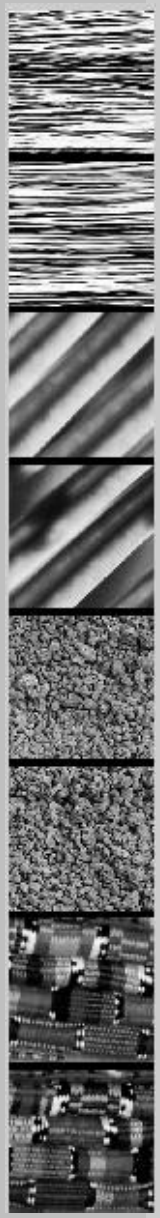

12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60



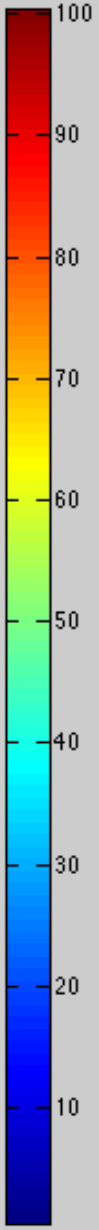

12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60


10000
5000
0
0
20
40
60





0	13	98	86	54	54	61	58
13	0	93	80	59	59	58	54
98	93	0	18	100	99	69	69
86	80	18	0	88	88	59	58
54	59	100	88	0	3	54	50
54	59	99	88	3	0	53	49
61	58	69	59	54	53	0	7
58	54	69	58	50	49	7	0



Local Binary Patterns

Examples
Face Recognition

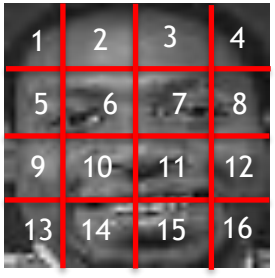
In the training set there are *k* classes.

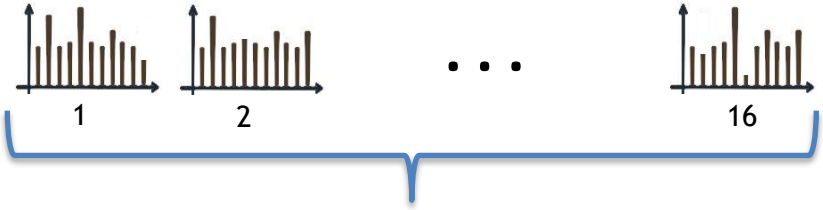
For each class we have *n* training images.

In this example there are 40 classes with 9 images each.

Each image we use w x *w* partitions

In each partition we extract LBP feature





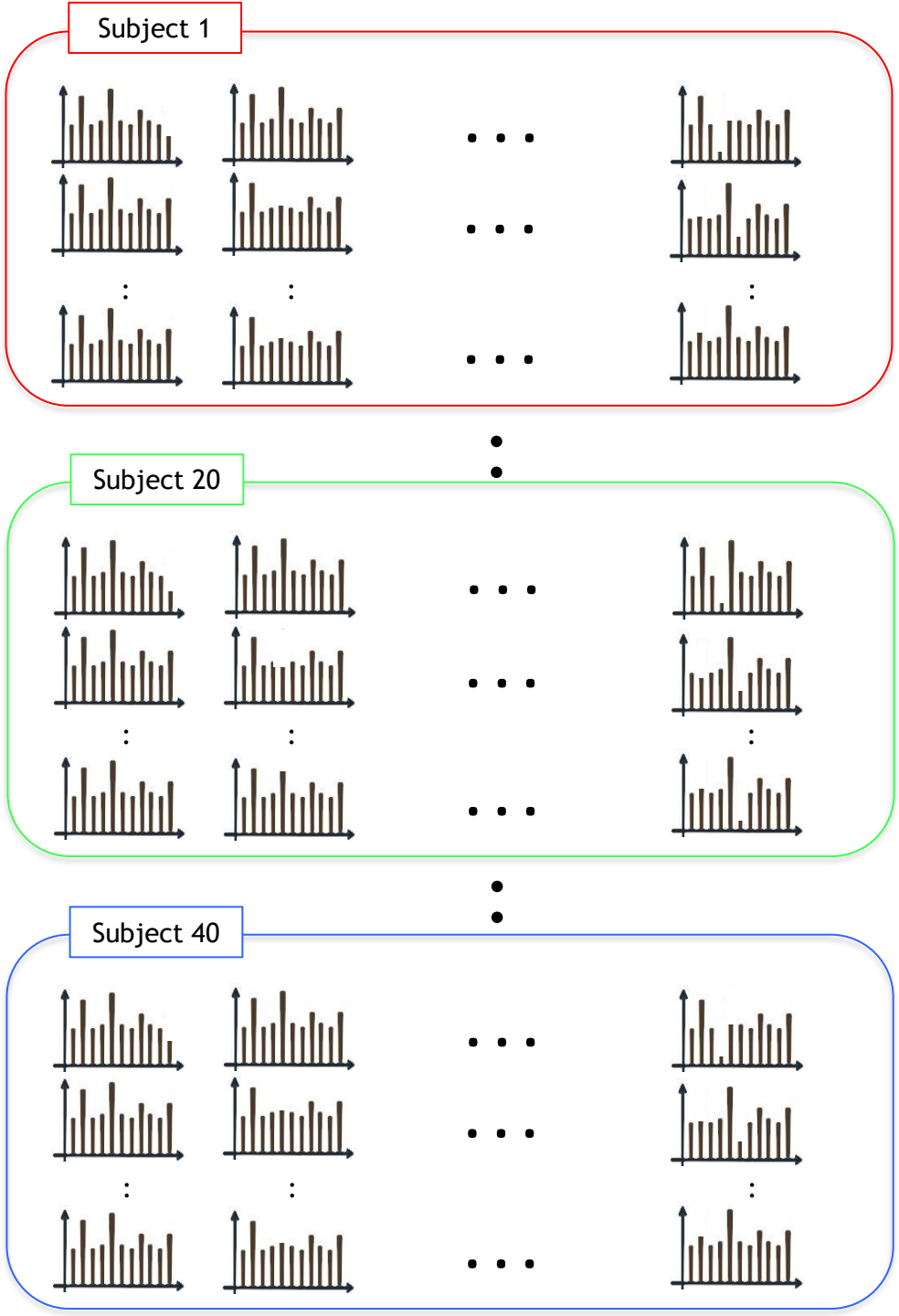
A face is described using a feature of 16 x 59 = 944 elements

Training Data:

Table with:

9x40 = 360 rows

16 x 59 = 944 columns

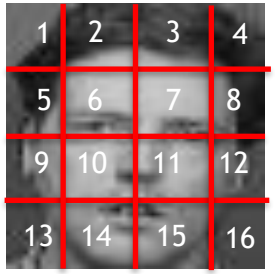

Subject 1
Subject 20
Subject 40

Subject 1

Subject 20

Subject 40

TESTING



Who is this subject?

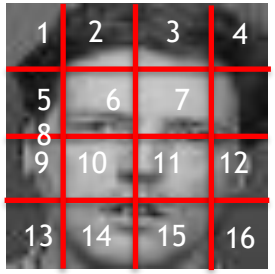
1 2 . . . 16

Subject 1

Subject 20

Subject 40

TESTING



Who is this subject?

Subject 1

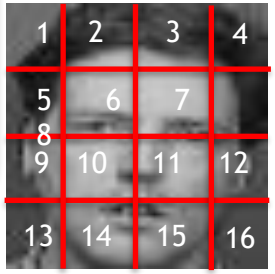
Δ

920

Subject 20

Subject 40

TESTING



Who is this subject?

Subject 1

Δ

920

781

699

Subject 20

73

65

99

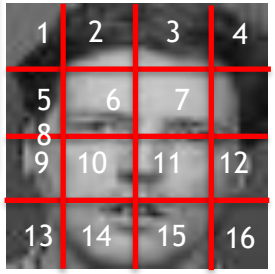
Subject 40

82

128

91

TESTING



Who is this subject?

Minimum

Strategy 1:
The nearest neighbor

Strategy 2:
k – nearest neighbors
(knn)

Subject 1

Δ

920

781

699

Subject 20

73

65

99

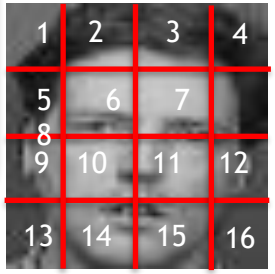
Subject 40

82

128

91

TESTING



Who is this subject?

2nd Minimum > Subject 20

1st Minimum > Subject 20

3rd Minimum > Subject 40

Strategy 2:
k-nearest neighbor (k=3)

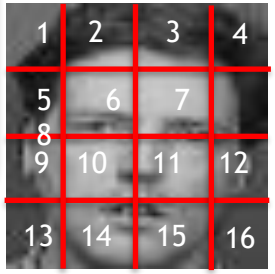
Strategy 3:
smallest sample-class distance

Subject 1

Subject 20

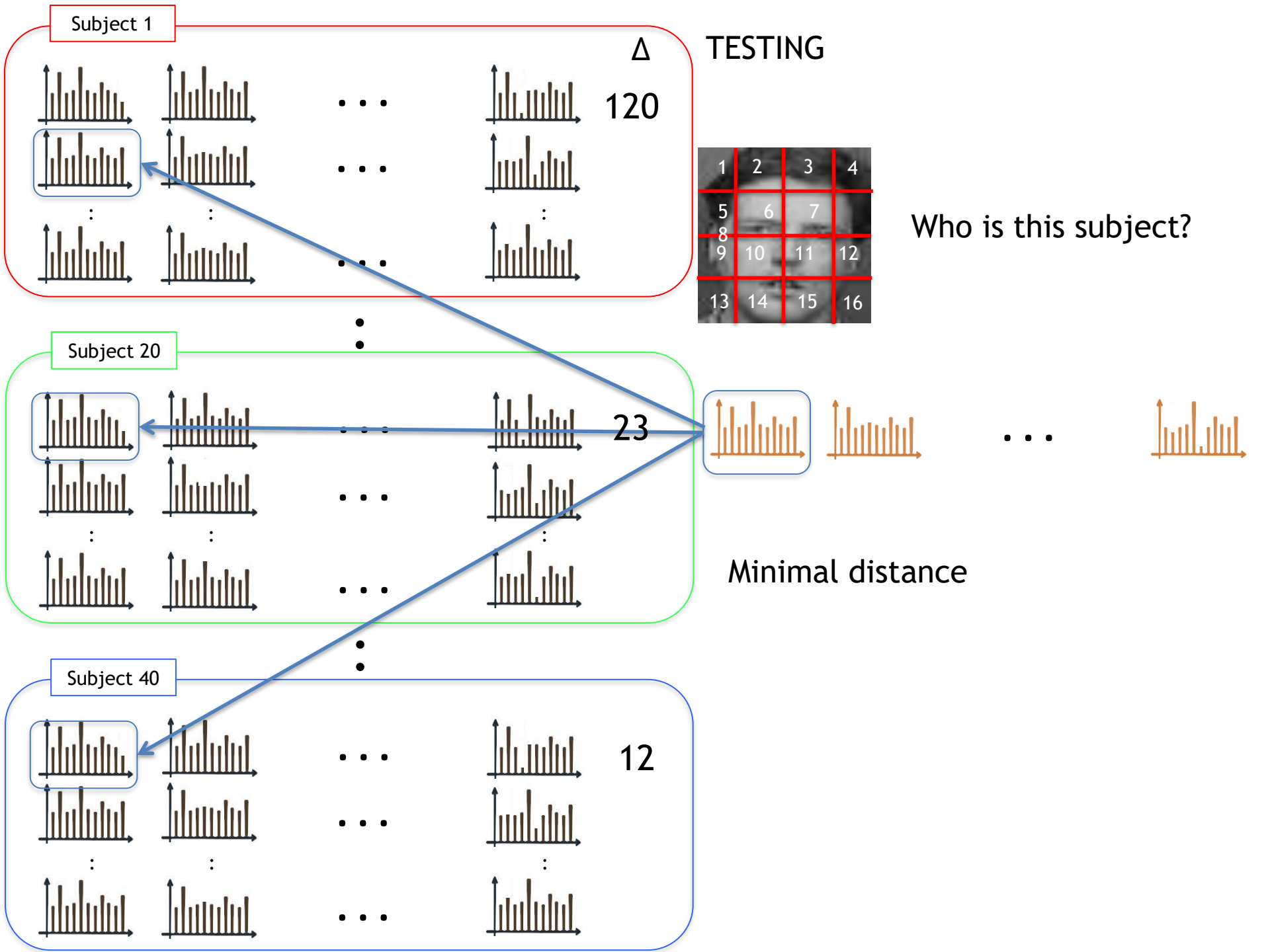
Subject 40

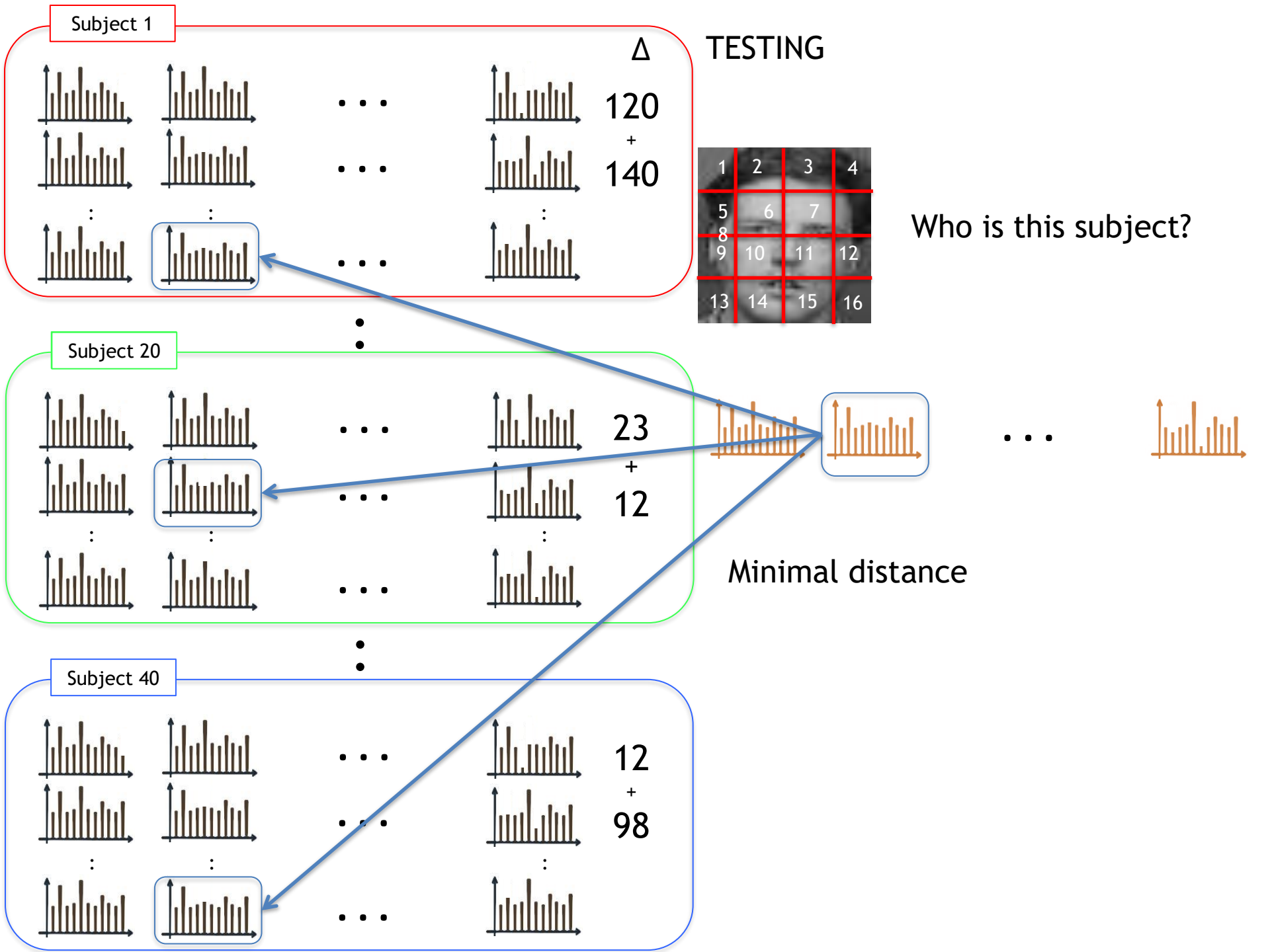
TESTING

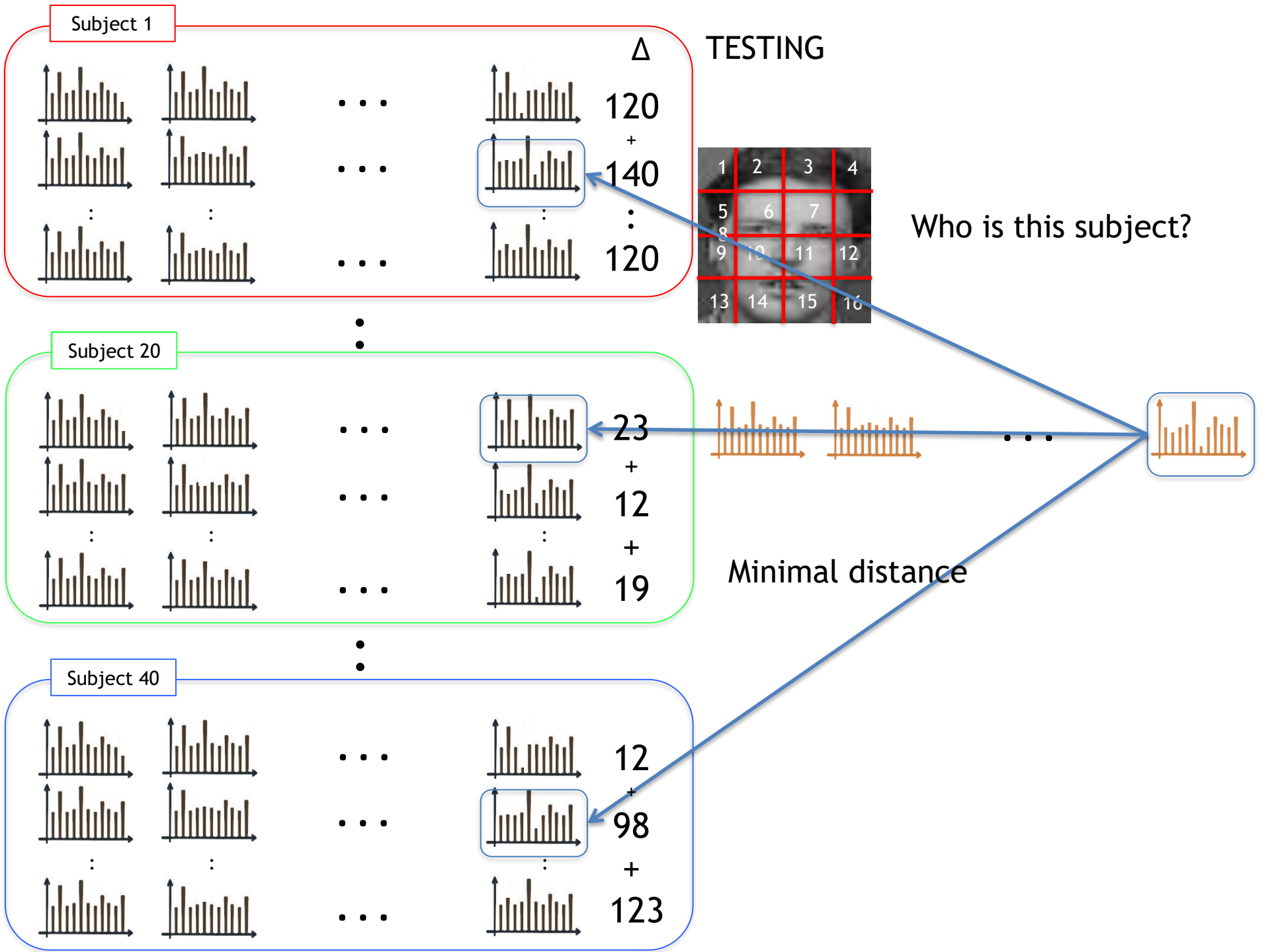


Who is this subject?

Minimal distance


Subject 1
Δ
120
TESTING
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Who is this subject?
Subject 20
23
Minimal distance
Subject 40
12


Subject 1
Δ
120
+
140
TESTING
1 2 3 4
5 6 7 8
9 10 11 12
13 14 15 16
Who is this subject?
Subject 20
23
+
12
Minimal distance
Subject 40
12
+
98


Subject 1
Δ
TESTING
120
+
140
:
120
1
2
3
4
5
6
7
8
9
11
12
13
14
15
16
Who is this subject?
Subject 20
23
+
12
+
19
Minimal distance
Subject 40
12
+
98
+
123

Subject 1

Δ

120

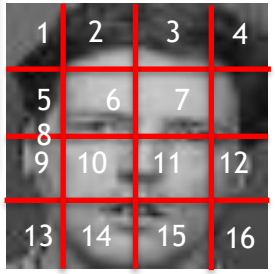
+

140

:

120

TESTING



Who is this subject?

Subject 20

23

+

12

+

19

= 54

Minimal total distance

Subject 40

12

+

98

+

123